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RICHARDSON'S GROUND SQUIRREL (*SPERMOPHILUS RICHARDSONII*) IN THE LARAMIE BASIN, WYOMING

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Abstract

Richardson's ground squirrel was studied in Laramie Basin, Wyoming (elev. 7,200 ft) from August 1966 to March 1969. Squirrels were active above-ground from early March to late August. Males apparently emerged about two weeks before females. High mid-day summer temperatures resulted in a daily bimodal activity pattern. Mean litter size was 5.9 (range 4 to 9) (N=69 females) based on embryos, placental scar counts and young born in captivity. Juvenile males had a larger home range (1.57 acres) than adults males (0.97 acres). Mean home range size for all squirrels was 0.81 acres. Density ranged from 1 animal per 12 acres in March to 1 per 2.1 acres in June. Based on monthly means, males weighed more than females at all times. The largest male was 536 g and the heaviest female was 473 g. Squirrels exhibited prominent seasonal trends in fatness. Fat reserves were greatest in July (5.30 ± 2.40 g in males and 4.86 ± 2.91 g in females). Spleen weights expressed as a percentage of body weights showed no significant seasonal fluctuation. Adrenal weights peaked in June.

Introduction

The Richardson's ground squirrel (*Spermophilus richardsonii*), a medium sized, diurnal rodent of the west-central and intermontane states has not been mentioned in the literature outside a few scattered species accounts. The purpose of this paper is to report on reproduction, home range, population characteristics, seasonal changes in body weight, fat deposition and spleen and adrenal gland weights of Richardson's ground squirrels in the Laramie Basin of southeastern Wyoming.

Method

Richardson's ground squirrels were studied for over two annual cycles of activity above ground (August, 1966; March-August, 1967-68; and March, 1969) on Hutton Lake National Wildlife Refuge and the surrounding area, Albany Co., Wyoming. Intensive live-trapping (Double-door National live traps) and observations were combined with collection of animals from nearby areas. Traps were moved to new locations within the study area at least weekly. During the sum-

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mer, traps were checked twice daily in an attempt to prevent mortality from high temperatures. Traps were baited with whole wheat. Upon first capture all ground squirrels were toe clipped and dyed with a Nynazol D in a manner similar to that described by Martinsen (1968). Toe clipping was necessary since dye patterns were altered or lost when animals molted. Data on sex, age, and general condition of each ground squirrel were taken at this time. In as much as evidence indicates that nearly all individuals of Richardson's ground squirrel breed in their second year, animals 10 months of age and older were considered adults and those less than 10 months were considered juveniles.

A 100 ft interval grid (1900 ft long and 800 ft wide) was staked on the study area. A white-tailed prairie dog (*Cynomys leucurus*) colony was also located within the grid. With the grid stakes used as reference points, it was possible to accurately plot the activities of Richardson's ground squirrels.

A total of 141 squirrels were examined for changes in reproductive organs associated with the annual reproductive cycle. After position of the testes or vaginal orifice and mammae were examined, species were preserved in AFA. Paired testes were measured (length in mm) and weighed to the nearest 0.01 g on a Mettler balance. Litter size was determined by counts of embryos or placental scars. Uteri were cleared with methyl salicylate. Ten-micron sections of testes were examined microscopically for seasonal changes in spermatogenic activity.

The "point-centered quarter" method devised for grasslands by Dix (1961) was used to sample the vegetation. Both species and lifeform of the vegetation were recorded (DuRietz, 1931).

One method used to determine home range was the greatest distance between points of capture of animals as the diameter of a circle which was considered as the home range area. Another home range method utilized was the minimum home range area plus estimate. In this method a line is drawn around the periphery of the outer points in such a way so as not to exclude areas where the ground squirrels might be expected but not been captured (Bradley, 1967).

Ground squirrels from other nearby populations were collected to supplement data from live trapping and observation. Bodies were fixed in AFA. The retroperitoneal fat, removed and weighed to the nearest one-tenth gram, below the diaphram and to the left of the dorsal aorta was taken as an index to the total amount of stored fat. This method has been used for the eastern woodchuck (*Marmota monax*) by Snyder, Davis and Christian (1961) and on round-tailed (*Spermophilus tereticaudus neglectus*) and Harris antelope (*S. harrisii harrisii*) ground squirrels by Neal (1965). The 141 squirrels used to study reproduction were also used for this portion of the study.

Spleen and adrenal glands were removed, cleaned of excess tissue and weighed to the nearest 0.001 gram. Spleen and adrenal weights

were expressed in per cent of body weight, thus permitting comparison of animals of different sizes.

Description of the Study Area

The study site is approximately 10 miles southwest of Laramie, Albany County, Wyoming, at an elevation of 7,200 ft. This area is in the Laramie Basin and falls within what Cary (1917) called "Transitional Life Zone" and Porter (1962) termed "Interior Grassland Plains." Long (1965) classified the area in the "Cheyenne Plains Faunal Division." The Laramie Basin consists of an arid mountain valley, 35 miles wide and 70 miles long surrounded on three sides by mountains.

The life-form of the vegetation of the study area based on percent of occurrence of each life-form element was 2.5 percent dwarf shrubs, 2.0 percent mid-grasses, 75.5 percent short grasses, 0.5 percent mid-forbs, and 7.5 percent Paramelia lichen. The species were mostly blue grama (*Bouteloua gracilis*), western wheat-grass (*Agropyron smithii*), several species of bluegrass (*Poa* spp.), junegrass (*Koleria cristata*), needlegrass (*Stipa* spp.), and prickly pear (*Opuntia polycantha*). Rabbit brush (*Chrysothamnus* spp.), greasewood (*Sarcobatus vermiculatus*), and saltsage (*Atriplex* spp.) were also present.

The climate is semi-arid. The average temperature based on a 30 year average (1931-1960) is 22.8 F for January (coldest month) and 63.8 F for July (warmest month). This area is characterized by an average growing season of 113 days. Mean annual precipitation is 11.14 inches (Alyea, 1967). Soils of the study site varied from shales to gravels, with the texture of the topsoil being silt loam, loam and fine sandy loam.

Results

Activity Patterns

Daily Activity:—Richardson's ground squirrel was completely diurnal. The pattern of daily activity was dependent upon the prevailing weather. The usual daily routine of an individual squirrel was somewhat as follows: the animal emerged from its burrow generally within an hour after sunrise. The animal sat or stood in, or near its burrow entrance and looked around for a few minutes, and then proceeded to forage within the proximity of the burrow, moving further away as the day lengthened. Many times during the day the squirrel returned to its burrow. During the warmest summer months (June, July, and August) the squirrel returned there until high mid-day temperatures dropped. As the late afternoon approached, the squirrel emerged from its burrow and began foraging again, returning below ground for the night.

As a colony squirrels were active throughout most of the entire day except when local weather restricted above-ground activity. The general pattern of daily activity varied throughout the season. Daily

activity observed early in the season (March, April, and May) was characterized by flat curves, peaking in early afternoon, while curves late in the season (June, July, and August) tended to be bimodal.

Seasonal Activity:—Each year the number of ground squirrels greatly increased above the number in the over-wintering population during early June when young animals appeared above-ground. The mean number of captures for individual animals by monthly periods provided an index to the relative amount of activity throughout the above-ground seasonal activity cycle. The mean number of captures increased from a low in March, to a high in May and then decreased in July (Figure 1). The lower average number of captures in March was probably due to the cold temperatures and frequent occurrence of snow storms. With an increase of warm weather, activity greatly increased to a peak in May.

Hibernation:—Emergence time of the first Richardson ground squirrel varied only slightly from year to year. Squirrels were first noted above-ground on 10 March, 1967; 8 March, 1968; and 13 March, 1969. Animals continued to emerge from hibernation over the following two to three weeks after the emergence of the first animal. All ground squirrels were active by late March. During March,

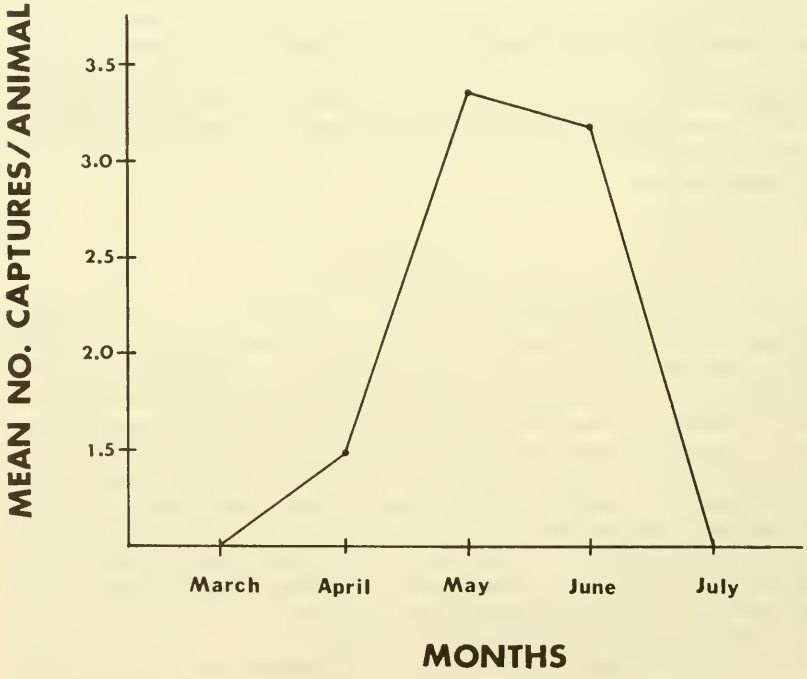

Fig. 1. The average number of captures per individual *Spermophilus richardsonii elegans* for monthly periods.

1968, 15 of the 18 animals collected were males, suggesting that males emerged from hibernation before females.

The number of squirrels active above-ground declined in early July of each year. A sex differential in the time of onset of hibernation did not appear to be marked. Possibly males began hibernating a week or so before females (first week in July for males), and by mid to late July all adults were below ground. By 26 August, 1966, and 25 August, 1967 and 1968, all above-ground activity terminated in all age and sex categories.

Estimates, therefore, can be made of the amounts of time spent in above-ground activity. Colonies in the Laramies Basin were active above-ground for about six months. No single individual was active throughout the full period. Adults were active for about four months and juveniles were active for about three months (June to August).

Activity in Relation to Abiotic Environment:—Large snow storms, which were common in March and April lasting often for several hours, were related to the squirrels disappearing below ground until the snow stopped falling. After these storms the amount of above-ground activity in the fresh snow was reduced.

Light rain showers, lasting only a few minutes, did not seem to affect above-ground activity. Heavy rains and hail storms caused a cessation of all above-ground activity.

Temperature was an important factor which regulated the intensity of the activity of the squirrels above-ground. Field observations showed that the squirrels were largely active within a temperature range of from 25 F-80 F. Captured squirrels began to salivate at about 80 F. Repeated salivation is related to drastic water loss (Bradley, 1967). Squirrels left in traps for a couple of hours at about 85 F died from over-heating and water loss. Approximately 85 F can be considered as the upper-most temperature at which activity above-ground can continue. However, animals were active for short periods of time, 10-15 minutes, at these high temperatures.

Reproduction

Females:—Females passed through a well-defined cycle of seasonal changes in reproductive organs similar to those seen in other *Spermophilus* (McKeever, 1965; Tomich, 1962; Neal, 1965). The sexual reproductive condition of 64 females is given in Table I. Females were considered to be in or near breeding condition if the vulva was open. The beginning of the breeding season in *Spermophilus beldingi* and *S. lateralis* is marked by enlargement of the vulva and the uterus (McKeever, 1965), and a similar cycle of changes also appears in Richardson's ground squirrel. In two squirrels collected on 17 March, their vulvae were closed. The vulva of a squirrel collected on 25 March was beginning to swell, and by 28 March, in 1967 and 1968, all females collected had swollen vulvae. After 15 April in both years, females were collected with vulvae not swollen.

Table I. Reproductive condition of 64 adult female Richardson's ground squirrels collected during two annual above-ground activity cycles (March-July, 1967-68) in the Laramie Basin of Wyoming.

Condition	March	April	May	June	July	Totals
Vulva Open	1	1	0	0	0	2
Vulva Closed	3	21	22	13	3	62
Pregnant	0	15	1	0	0	16
Embryos:						
No.	0	81	5	0	0	86
Mean	0	5.4	5.0	0	0	5.3
Range	0	4-9	5	0	0	4-9
Placental Scars:						
No.	0	23	121	81	18	243
Mean	0	7.0	5.8	6.2	6.0	6.1
Range	0	7-8	4-9	5-8	5-7	4-9
No. without Litters or Scars						
Lactating	4	3	0	0	0	7
No. of Animals	0	4	19	0	0	23
Examined	4	22	22	13	3	64

Therefore, breeding occurred from about 20 March to 15 April each year. Females were pregnant only during April and early May. Adult females entered estrus and bred at approximately the same time.

Litter size *in utero* ranged in number from four to nine, with a mean of 5.3. Placental scars ranged from five to nine (mean 6.1). The mean numbers based on both embryos and placental scar counts in 56 females was 6.06. Five pregnant females, brought into the laboratory, gave birth in late April and early May, 1968, and the average litter size was 6.0 (5-8). Denniston (1957) reported a mean litter size of 7.0 (5-9) for six litters of Richardson's ground squirrels born in captivity. Previously published data and records on litter sizes by Warren (1910), Burnett (1916 and 1920), Day (1923), Howell (1938), Denniston (1957), and Hall and Kelson (1959) on Richardson's ground squirrel showed the number of embryos, placental scars, or young to vary from 4.6 to 8.2. In the present study, the mean litter size was 5.88, determined from embryo counts (N=16), placental scars (N=40), and litters born in captivity (N=5).

Lactation and the presence of placental scars appeared simultaneously. Juveniles were emerging from their nest burrows by June, after which no lactating females were found.

Males:—Comparison of the monthly mean weight of paired testes showed one annual period of peak development. Mean testes weights varied from a high of 1.8 g (1.08-2.65) in March, to 0.73 g (0.34-1.80) in April, and to a low in May of 0.15 g (0.11-0.22). After the decrease, testes gradually increased slightly in weight to 0.16 g in June range (0.14-0.20) and at the onset of hibernation in July they weighed 0.16 g (0.14-0.20). Testicular enlargement before hibernation has been noted in *Spermophilus* by Tomich (1962), McKeever (1963, 1964) and Wells (1935).

Trends in length of the paired testes exhibited a single peak curve similar to testes weight. Lengths of the testes were greatest in March (mean 20.0 mm, 18-22), decreased in length to 13.5 mm (11-20) in April, 8.3 mm (7-9) in May, to a low of 7.6 mm (7-8) in June, and increased to 8.5 mm (8-9) by July.

Testes, considered scrotal if they had descended or could be moved into a scrotal position by external manipulation, had descended in adult males by 17 March, 1968, nine days after squirrels were first emerged from hibernation. The last individual with scrotal testes was noted on 6 April, 1967. The position of the testes of squirrels at the time of emergence from hibernation was not determined, but *Spermophilus beldingi* has scrotal testes and is sexually active at the time of spring emergence (McKeever, 1965). Periods that the testes were scrotal generally coincide with the time when the vulvae were open and swollen (Table I).

Histological changes in the testes follow the same general cycle associated with testes lengths and weights. In mid to late March, when all of the males (N=15) possessed scrotal testes, fully mature spermatozoa were present in the seminiferous tubules. After the breeding season, regression of adult male testes in late March and early April followed the pattern as described by Bakko and Brown (1967), for the white-tailed prairie dog.

Home Ranges

The mean maximal distance traveled by the squirrels in feet was plotted on a graph against the number of successive points of observations or captures (Fig. 2). When a home range had 10 or more points of observation or capture, generally, the size of home range did not increase greatly with additional captures or observations. Data for the nine Richardson's ground squirrels that had at least a minimum of 14 points (the maximum was 49 points) were used to calculate home range.

The mean home range in acres for the nine males was 1.09, calculated by the method of greatest distance between captures. No female was captured 14 times, the minimal number used to establish home range. The home ranges of these males varied from 0.50 to 1.78 acres. Mean home ranges varied between age groups of these nine males. Three males less than 10 months of age had an average home range of 1.57 acres, whereas, two one-year-old males had only 0.97 acres, an area only 62 percent as large as tha tof juvenile males. The four remaining males were adults of unknown ages with an average home range area of 0.91 acres (58 percent of the size of juvenile males).

The same nine male ground squirrels used in determining home range by the greatest distance between captures were also used for calculation of home range size by the method of minimal home range plus an estimate. The mean home range size for these nine animals was 0.53 acres, only 48 percent of the average home range

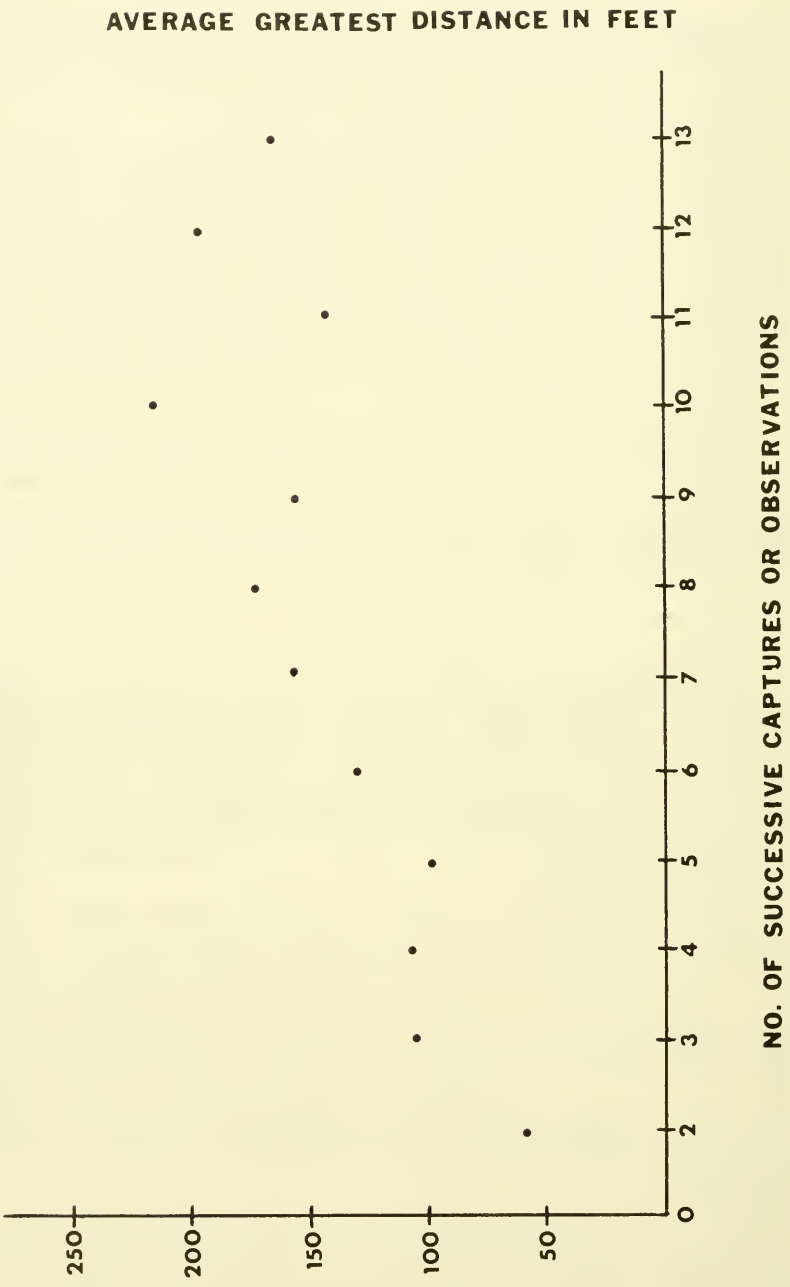

Fig. 2 Average distance of movements of Richardson ground squirrels grouped by successive captures.

Table II. Seasonal changes in the body weights of *Spermophilus richardsonii elegans* in grams

	Adult Males				Adult Females			
Period[1]	No.	Mean	S	Range	No.	Mean	S	Range
March	15	279	±53.6	210-390	3	203	±32.1	180-240
April	14	266	±40.8	230-350	21	247	±69.2	100-360
May	20	308	±60.9	250-460	22	287	±39.5	211-347
June	16	394	±69.9	292-536	12	345	±51.0	250-437
July	3	400	±20.0	380-420	2	320	±22.3	300-330
Total	68				60			

1. No adult ground squirrels were observed above-ground before 8 March (1968) or after late July 1967 and 1968. They were presumed to be below ground hibernating.

area determined by the greatest distance between capture methods. Home ranges varied from 0.10 to 1.21 acres. Home range determined by this method reveals irregular areas in which the animals were generally known to occur. Age differences were also noted in home range areas calculated by this method. Juvenile males occupied 0.78 acres, whereas, one-year-old males averaged 0.36 acres (46 percent of that of juveniles) and other males (adults age unknown) averaged 0.52 acres, only 67 percent of that of juvenile males.

An average for all males of the mean home range areas in acres determined by both methods showed a home range size of 0.81 acres. Generally, juvenile males had a much larger home range area than did adult males. Data from animals caught in both 1967 and 1968 showed that generally the home range of individuals tended to remain in the same geographic area from year to year.

Transplants and Homing

Four transplants were made. In early April, one male and one female were captured in an area adjacent to the study site and were transplanted ¼ mile away from their points of capture. The female returned the next day, and the male was never seen again. Two males of undetermined age were introduced into the study colony in late April. One of these disappeared from its point of release within 3 days after it was transplanted. The other was captured and observed a total of 28 times over a 3 month period and apparently became established in the area to which it was released.

Population Characteristics

Numbers and Density.—A total of 28 squirrels were captured and marked on the study colony. An additional 141 were collected from adjacent areas. Animals captured on the study colony represented almost 5,000 trap-days.

The number of ground squirrels per acre was used as a measure of density (Blair, 1951). Only resident animals as defined by Mc-

Carley (1958) were used in the calculation of density. Density figures ranged from one animal per 12 acres in March to one animal per 2.1 acres in June.

Mortality.—Twelve ground squirrels were marked by July, 1967; eight (66.6 percent) were still present on the study area in April, 1968; and six (50 percent) were there in July, 1968. Predation (by badgers, eagles, and hawks) and live-trapping procedures caused five deaths. Long-tailed weasels, which were abundant in the area, may have accounted for some mortality. Mortality, probably, is highest during the over-wintering dormancy.

Sex ratios.—One hundred and thirty-five squirrels were used to calculate sex ratios, and of these 54 percent were males. Figure 3 shows the sex ratio by months throughout the seasonal activity cycle. During the first and last month (March and July) of the seasonal activity cycle, sex ratios departed greatly from a 1:1 ratio. This was probably due to a differential time of arousal and onset of hibernation between the sexes.

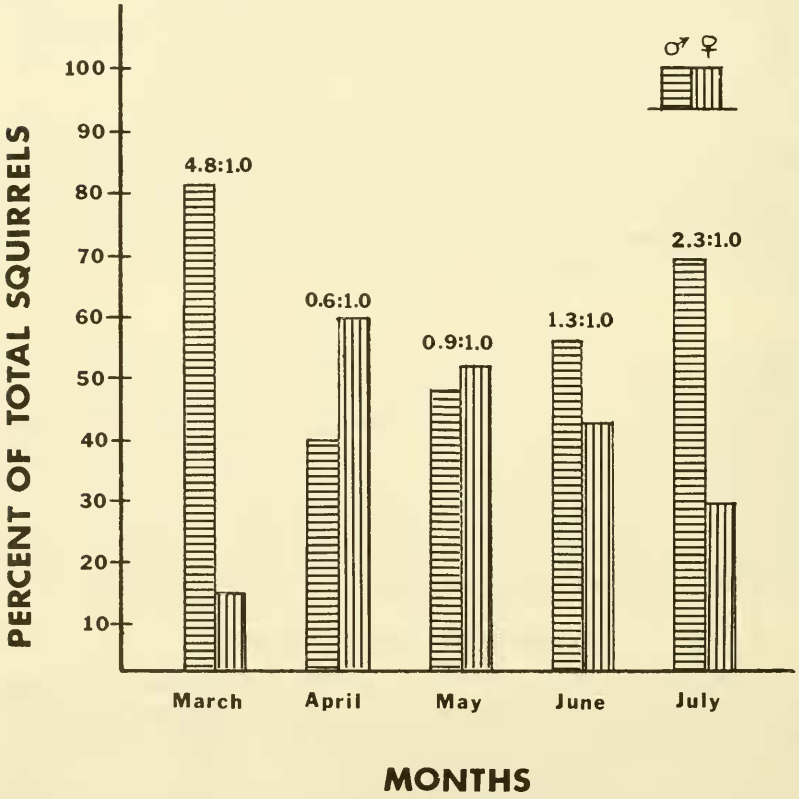

Fig. 3. Sex ratios of *Spermophilus richardsonii elegans* by monthly periods.

Seasonal Body Weight Changes

In 1968, adult males emerged from hibernation approximately two weeks before adult females. Based on monthly means, adult females generally weighed about 20 percent less than adult males of the same period throughout the seasonal activity cycle (Table II). The largest male Richardson ground squirrel weighed 536 g, and the next four largest males weighed 470, 460, 420, and 400 g. The heaviest female weighed 437 g, and the four next largest ones weighed 411, 392, 379, 370 g. A male rarely weighed more than 380 g, or a female more than 340 g. The smallest adult male weighed 210 g, whereas, the smallest female weighed 100 g. Both of these animals were collected shortly after they emerged from hibernation.

Seasonal Changes in Fat Deposition

There is wide variation in the body weights of Richardson's ground squirrel because of differences in age and growth rates of the young and also because adult body sizes of both sexes is highly variable: the basic body unit sustains a remarkable seasonal cycle of fat deposition and utilization. Any study of body mass must consider stores of fat (Tomich, 1962).

Upon emergence from hibernation in March all specimens possessed some fat reserve. During the following two to three months, males and females utilized their fat reserve (Table III). Based on monthly means, males reached a low in fat reserve in April and females in May. Males at first appearance above-ground possessed a larger mean fat reserve than did females (Table III). By July (hibernation) females possessed larger quantities of fat than males.

Males during March possessed a mean fat depot in grams of 5.17 $\pm$ 2.63 (0.5-10.4). and this diminished to a low of 0.15 $\pm$ 0.34 (0.0-1.1) in April. In May, the mean fat depot increased to 0.41 $\pm$ 0.55 (0.0-1.6), by June, it was 2.71 $\pm$ 0.94 (2.0-3.8) and was at its largest in July, when it was 5.30 $\pm$ 2.40 (2.6-7.2).

In females, the mean fat depot was 3.50 $\pm$ 2.40 (0.8-5.3). This fat depot decreased to 0.18 $\pm$ 0.34 (0.0-1.0) in April and then rose to 0.45 $\pm$ 0.17 (0.0-0.5) in May, then jumped to 4.38 $\pm$ 4.25 g (.02-8.7) in June, and rose to 4.86 $\pm$ 2.91 (1.8-7.6) in July.

Table III. Seasonal changes in the weight of the left abdominal fat depot of *Spermophilus richardsonii elegans* expressed as a percentage of body weight.

	Adult Males				Adult Females			
Period	No.	Mean	S.	Range	No.	Mean	S.	Range
March	14	1.94	±.87	.32-3.47	3	1.71	±1.20	.43-2.50
April	9	.30	±.23	.13- .46	13	.41	± .27	.13- .67
May	9	.34	±.11	.22- .41	11	.18	± .04	.15- .21
June	3	.82	±.22	.68-1.07	3	1.27	±1.33	.06-2.69
July	3	1.34	±.63	.62-1.80	3	1.54	± .99	.55-2.53
Total	38				33			

The general pattern of fat deposition is similar to that described by Hamilton (1934) for the eastern marmot, as follows: first, fat is laid down in the inguinal region; it then spreads out to cover the rump it also commences on the shoulders, the two regions may be joined finally as a single layer. The region of the heaviest coating lies over the hind legs and the rump. Coincidentally, a rapid proliferation of fat about the genital organs and the kidneys occur. Immediately prior to hibernation, the internal organs caudal to the diaphragm are concealed in a white mantle of fat.

Seasonal Changes in Spleen Weights

Spleen weights expressed as a percentage of body weights showed no large fluctuation (Table IV). In March, the mean splenic weight in grams for males was 0.76 ± 0.24 (0.31-1.27). The mean weight in April was 0.96 ± 0.19 g (0.70-1.30), and in May it was 1.21 ± 0.49 (0.84-0.23). In June, it dropped to 1.10 ± 0.56 g (0.30-1.52).

In females, the mean splenic weight for March was 0.63 ± 0.33 (0.36-1.00), in April, 1.10 ± 0.19 (0.71-1.19), in May, 1.26 ± 0.32 g (0.62-1.62), and was at a peak in June, when it was 1.28 ± 0.38 (0.83-1.57).

Table IV. Seasonal changes in splenic weights expressed as a percentage of body weight in relation to sex in *Spermophilus richardsonii elegans.*

	Adult Males				Adult Females			
Period	No.	Mean	S.	Range	No.	Mean	S.	Range
March	15	.28	± .085	.12-.38	3	.30	± .111	.20-.42
April	8	.35	± .103	.23-.54	12	.43	± .180	.21-.71
May	9	.45	± .182	.22-.68	11	.40	± .138	.20-.59
June	4	.31	± .133	.08-.52	3	.36	± .102	.24-.43
July	....	....	....	.....	....	....	....	.....
Totals	46				39			

Seasonal Changes in Adrenal Weights

Both male and female Richardson ground squirrels reached a peak in adrenal weights, expressed as a percentage of body weight, in June, shortly before entering hibernation. At this time (June) adrenal weights were at least twice as great as at other times of the above-ground activity cycle for which sufficient data exists (Table V).

Shortly after emerging from hibernation the mean adrenal weight in grams of the males for March was 0.058 ± 0.020 (range 0.03-0.10 g), in April the mean was slightly greater being 0.064 ± 0.026 (range 0.04-0.12). The mean value dropped in May to 0.040 ± 0.019 (range 0.02-0.06) and increased sharply in June to 0.144 ± 0.047 (range 0.09-0.20).

In females, the mean adrenal weight for March was 0.047 ± 0.011 (range 0.04-0.06 g). The mean in April was 0.038 ± 0.013

Table V. Seasonal changes in adrenal weights expressed as a percentage of body weight in relation to sex in *Spermophilus richardsonii elegans.*

Period	Adult Males				Adult Females			
	No.	Mean	S.	Range	No.	Mean	S.	Range
March	13	.02	± .008	.01-.04	3	.02	± .007	.02-.03
May	7	.01	± .040	.01-.05	10	.02	± .009	.01-.04
April	4	.03	± .009	.01-.02	6	.02	± .019	.01-.03
June	4	.04	± .005	.03-.05	3	.05	± .020	.03-.07
July	1	.02	....	.....	....	....	....	.....
Totals	28				22			

(range 0.02-0.06), increasing somewhat by May to 0.059-0.015 (range 0.04-0.08), and was 0.169 ± 0.051 (range 0.11-0.22) in June.

Discussion

Apparently the male Richardson's ground squirrel emerges from hibernation a week or so before the female does. This differential pattern in arousal time between the sexes of ground squirrels of the same species has been noted by Scheffer (1941) in *S. townsendi* and *S. washington*, and by Manville (1959) in *S. columbianus*.

Davis (1939) observed that on 21 July, Richardson's ground squirrel in Idaho, was active from sunup to almost 9 AM at which time it returned to the burrow and then reappeared in the late afternoon. Seton (1929) noted that when temperatures reached near 85 F, Richardson ground squirrels disappeared below ground in their burrows. This was also the general pattern of daily activity observed in Richardson's ground squirrel during the summer months in the Laramie Basin of Wyoming.

Day (1923) reported that Richardson's ground squirrel first appeared above ground in May or early June in Wyoming, and Warren (1910) noted the first appearance around 1 April, in Colorado. Results of this study showed that ground squirrels emerged from hibernation about two months earlier than the dates reported by Day (1923).

Adults went into hibernation during July, and young disappeared by late August in the Laramie Basin of Wyoming. In Nevada, Borell and Ellis (1934) reported that the Richardson's ground squirrel was active in late August. Tanner (1927), in Utah, stated that by 8 August about 90 percent of Richardson's ground squirrels had gone into "aestivation" and those remaining out were young of the year.

The onset of hibernation in Richardson's ground squirrel during this study was related to large accumulated fat depots. In the thirteen-lined ground squirrel, after fat layers reached a maximum, hibernation occurred regardless of environmental stimuli (McCarley, 1966).

Published home range information on ground squirrels is limited. Home range size for Richardson's ground squirrel averaged 0.81 acres. Evans and Holdenreid (1943) reported a home range of 0.36

acres for males and 0.59 acres for females of *S. beecheyi*. *S mohavensis*, a desert ground squirrel, was reported to have a home range in excess of 3 acres by Burt (1930). Hawbecker (1958) found a home range of about 11 acres for *S. nelsoni*. Home range of *S. leucurus* has been given as 11.7 to 19.5 acres by Jorgensen and Hayward (1965) and 14.9 to 20.6 acres by Bradley (1967). McCarley (1966) found a home range size of 11.7 $\pm$ 2.1 acres for males and 3.5 $\pm$ 0.5 acres for females of *S. tridecemlineatus*.

The sex ratio of males to females found in Richardson ground squirrels during this study was 1.0:1.1. Several other studies on ground squirrels have shown some deviation from 1.0:1.0 sex ratios. McCarley (1966) reported a 1.0:2.8 and believed these to be somewhere near the actual sex ratio in *S. tridecemlineatus*. A 0.7:1.0 ratio was found by Mayer (1953) in *S. barrowensis*.

Both adult males and adult females steadily gained weight from a low body weight at the time of spring emergence (March) until their entrance into hibernation (July), except that males in April, showed a slight drop in body weight. Neal (1965) found that male *S. tereticaudus*, a hibernator, maintained its body weight during the first three months (January, February, and March) after appearance above-ground, then for the next two months, April and May, the weight increased and then dropped for the month of June, increased again in July and August and finally, in September prior to hibernation dropped again. Female, *S. tereticaudus* lost weight after emerging from hibernation during the first two months, then their weight increased steadily until September except for a drop from May to June attributed to the stress of nursing and caring for young.

Richardson's ground squirrel exhibit seasonal trends of fat deposition. This general pattern is evident in many hibernating squirrels (*S. beecheyi*, Tomich, 1962; *S. tereticaudus*, Neal, 1965; *Marmota monax*, Snyder, Davis, and Christian, 1961; and *Cynomys leucurus*, Clark, 1969; unpublished).

The process of fat deposition in the Richardson's ground squirrel seems similar to that described by Hamilton (1934) and Snyder, Davis, and Christian (1961) for the eastern woodchuck.

Several investigators have studied splenic and adrenal hypertrophy, especially as possible indicators of various kinds of stress (Chitty, 1960; Christian, 1963). In Richardson's ground squirrel no clear-cut distinction can be made between the sexes as far as splenic hypertrophy is concerned. Data seem to show that splenic weights are highly variable. No splenic hypertrophy was noted during the breeding season, during pregnancy, or lactation. Davis, Beer, and Cook (1961) noted that spleen size increased up to 50 percent in late pregnancy in *Peromyscus*. A similar phenomena was not encountered in Richardson's ground squirrel. If adrenal size reflects stress in a direct manner then males should undergo some stress during the breeding season, while females are subjected to about the same amount of environmental pressure before, during and after the breed-

ing season. In the thirteen-lined ground squirrel, there is a significant increase in adrenal weight during the breeding season (Zalensky, 1934). Anthony (1953) could find no seasonal trend in his analysis of adrenal weights in the male black-tailed prairie dog (*Cynomys ludovicianus.*).

The increase in adrenal weights in adult females in June may be an indication of the effect felt as a result of the young prior to their initial emergence from the nest where crowding might exist. In males possibly this crowding was not felt until young were aboveground and fully active during late June and early July. Behavioral responses to crowding might result in dispersal in young. In contrast with the round-tailed ground squirrel, Lyman et al. (1955) and Neal (1965), the Richardson's ground squirrel increased its adrenal weight immediately prior to hibernation.

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